Chapter 2

Data Communication

Computer generates a lot of information through data processing. The information is not useful in itself. It has to be communicated to the people. This information, also known as, data (text, audio or video) must be delivered to the people at the right time. It is important to transmit the information from one location to another at a very fast speed. This process is known as data communication. The computing devices such as computer, tablet and mobile devices are used to send the digital data. Advances in communication technology, combined with rapidly evolving computer technology, have made enormous progress in this field.

Electronic communication consists of telecommunication and data communication. Telecommunication refers to the use of telephone, telegraph, and radio or television facility to transmit information, either directly or via computer. Data communication means the transfer of data or information between computing devices. In this chapter, we will study the various modes of data communication.

Data

Data refers to the raw facts that are collected and processed to deduce information, while information refers to processed raw data that enables us to take decisions. For example, when exam results are declared they contain data of all students. This data provides the relevant information that whether a student passed or failed.

Data representation

Data can be represented in various forms such as.

- Text: It includes combination of alphabets in small case as well as upper case. It is stored as a pattern of bits.
- Numbers: They are a combination of digits from 0 to 9. It is stored as a pattern of bits.
- Images: In computers images are digitally stored in the form of pixel. Pixel is the smallest element of an image. A picture or image is a matrix of pixel elements. The size of an image depends upon the number of pixels (also called resolution). Commonly used image formats are jpg, png, bmp, etc.
- Audio: This data is in the form of sound which can be recorded and broadcasted. Audio data is continuous, not discrete.
- Video: It refers to broadcasting of data in form of picture or movie.

Types of electronic communication

Electronic communication is divided into two types.

(a) Data communication: The transfer of data between two points is called data communication.

(b) Telecommunication: When the transmission of data can take place from a long distance by means of towers, satellite or microwave system it is called telecommunication.

Data communication

To make communications possible using computers, there must be a signal translator called a modem. The modem, which is short for modulator and demodulator, first converts digital signals into analog and again back to digital signals which enables information to move across the telephone line.

Using electricity, radio waves or light, information and data in the form of codes are transmitted through a physical medium such as wire, cable, or even the atmosphere.

In a computer network, computers, printers, scanners and cameras are connected. Computers can exchange and share information and resources. Using hardware and software, these interconnected computing devices can communicate with each other through defined rules of data communications. A computer network may operate on wired connections or wireless connections. Networks are communication systems designed to transmit the information from origin to destination.

Characteristics of data communication

The effectiveness of a data communication system depends on three fundamental characteristics.

Delivery

The data should be delivered to the correct destination and correct user.

Accuracy

The communication system should deliver the data accurately, without introducing any errors. The data may get corrupted during transmission affecting the accuracy of the delivered data.

Timeliness

The system must deliver data in a timely manner. Data delivered late is useless. In the case of video, audio and voice data, timely delivery means delivering data, in the same order that they are produced, and without significant delay. This kind of delivery is called real-time transmission.

Components of data communication

The transmitter sends the message and the receiver receives the message. The medium is the channel over which the message is sent and the protocol is the set of rules that guides how the data is transmitted from encoding to decoding. The message is the data that is being communicated. Fig 2.1 shows the basic components of communication system. These are—

(a) Transmitter
(b) Receiver
(c) Medium
(d) Message
(e) Protocol

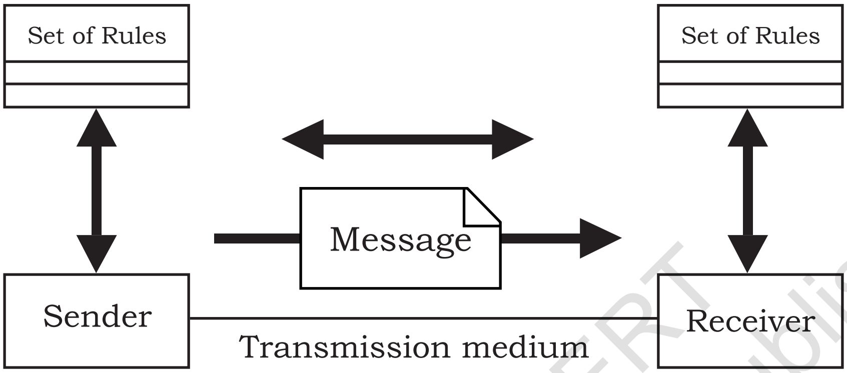


Fig. 2.1: Components of a data communication system

Sender or Transmitter

The sender is the device that sends the message. It can be a computer, workstation, telephone handset, video camera, and so on.

Receiver

The receiver is the device that receives the message. It can be a computer, workstation, telephone handset, television, and so on.

Transmission Medium

The transmission medium is the physical path by which a message travels from sender to receiver. It can be wired or wireless and many subtypes in both. It consists of twisted pair wire, coaxial cable, Fibre-optic cable, laser or radio waves.

Message

Message is the information to be communicated by the sender to the receiver.

Protocol

A protocol is a set of rules that governs data communication. A Protocol is a necessity in data communications. Without a protocol, two devices may be connected but not communicating, just as a person speaking English cannot be understood by a person who speaks only Marathi.

Modes of data communication

Two devices communicate with each other by sending and receiving data. There are three modes of data communication according to their way of communication.

(a) Simplex
(b) Half Duplex
(c) Full Duplex

Simplex

In simplex mode, communication is unidirectional shown in Fig. 2.2. Only one device sends the data while the other one only receives the data. For example, while watching television (TV), we can receive the information from TV. It sends or transmits the information in unidirection to the audience.

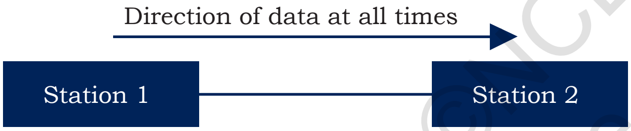


Fig. 2.2: Simplex mode of communication

Half duplex

In half duplex both the stations can transmit as well as receive but not at the same time as shown in Fig. 2.3. When one device is sending the other can only receive and vice-versa. Walkie-talkie is an example of a half duplex device. It has a "push-to-talk" button which is used to turn on the transmitter and turn off the receiver. It can either transmit or receive the information at a time. An advantage of half duplex is that the single track is cheaper than the double tracks.

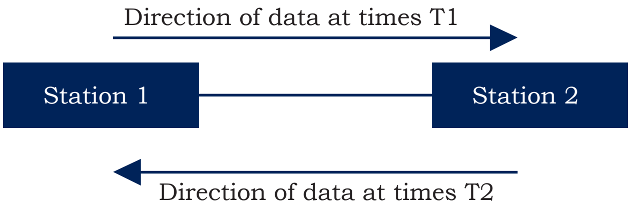


Fig. 2.3: Half duplex mode of communication

Full duplex

A full duplex communication mode is able to transmit data in both directions at the same time as shown in

Fig. 2.4. For example, during the telephone conversation people at both ends of a call can speak and be heard by each other at the same time. Thus, the full duplex mode increases the efficiency of communication.

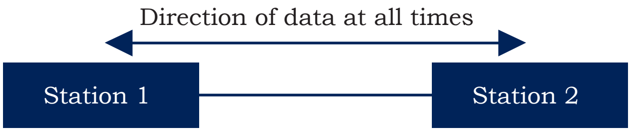


Fig. 2.4: Full duplex mode of communication

Data and signals

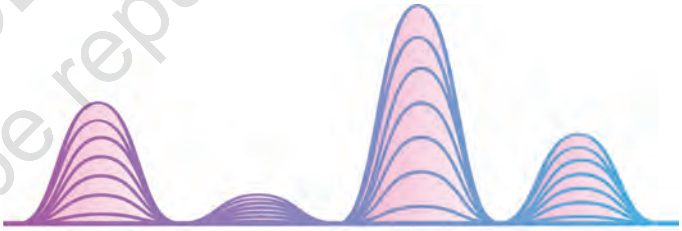
The information stored in computer systems and transferred over a computer network can be divided into two categories: data and signals. Data are entities that convey meaning within a computer or computer system. To transfer this data from one point to another, either by using a physical wire or by using radio waves, it has to be converted into a signal. Signals are the electric or electromagnetic encoding of data. Signals are used to transmit data.

Types of data

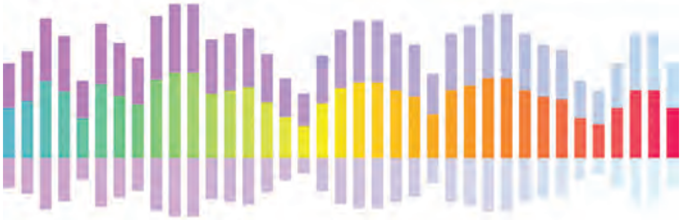
There are basically two types of data – analog and digital, used in data communication shown in Fig. 2.5.

Analog data — The data which is represented in physical properties and can be expressed as any value along a continuous scale is called analog data. The sound made by a human voice and analogue clock are the simple examples of analog data.

Digital data — Discrete and discontinuous representations of information are called digital data. Most electronic devices such as digital clock, calculators, computers, cameras and mobile phones store and process data in form of numbers which is called digital data. These numbers are in form of binary number meaning 0 and 1, represent the switches for power on or off. For example, when we store the audio data in form of ones and zeroes, the audio devices such as CD Players, etc., read these ones and zeroes and translate them into actual signals.



Analog signal



Digital signal

Fig. 2.5: Analog and digital data

Signals

In data communication, signals are used to send the data from one location to another. Signals are electromagnetic or light rays which carry the data. The simplest form of signal is a direct current (DC) that is switched on and off.

Classification of signals

Signals can be classified as

- (i) Electrical Signal
- (ii) Optical Signal
- (iii) Electromagnetic Signal

Electrical signal

Electrical signals communicate between two electrical devices. Electrical signal is the way of transferring the information through use of electricity which carries the message. Microphones, fax machines, remote controls for television sets, etc., are some of the examples of the devices using electrical signals.

Optical signal

Optical signal is the advanced technology in which data travels by means of electric voltage over the optical fibre.

Electromagnetic signal

Electromagnetic signal builds with two components, one is electric energy and the other is magnetic wave which are perpendicular to each other in an electromagnetic wave. Electromagnetic signal travels through the free space, as in wireless networking.

Transmission media

Transmission media is a means by which a communication signal is carried from one system to another as shown in Fig. 2.6. Transmission or communication media can be divided into two categories— physical or conducted media, such as wires, and radiated or wireless media, which use radio waves. Conducted media include

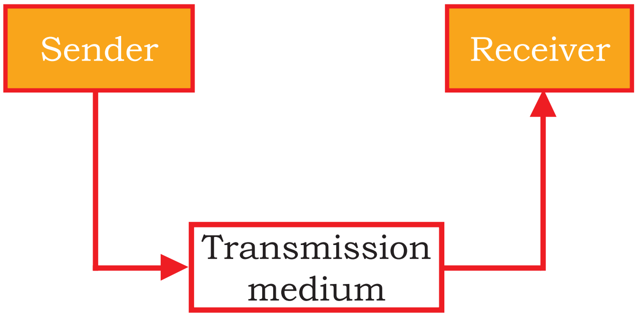


Fig. 2.6: Transmission of data from sender to receiver through a medium

twisted pair wire, coaxial cable, and fibre optic cable. In wireless transmission, different types of electromagnetic waves, such as radio waves, are used to transmit signals.

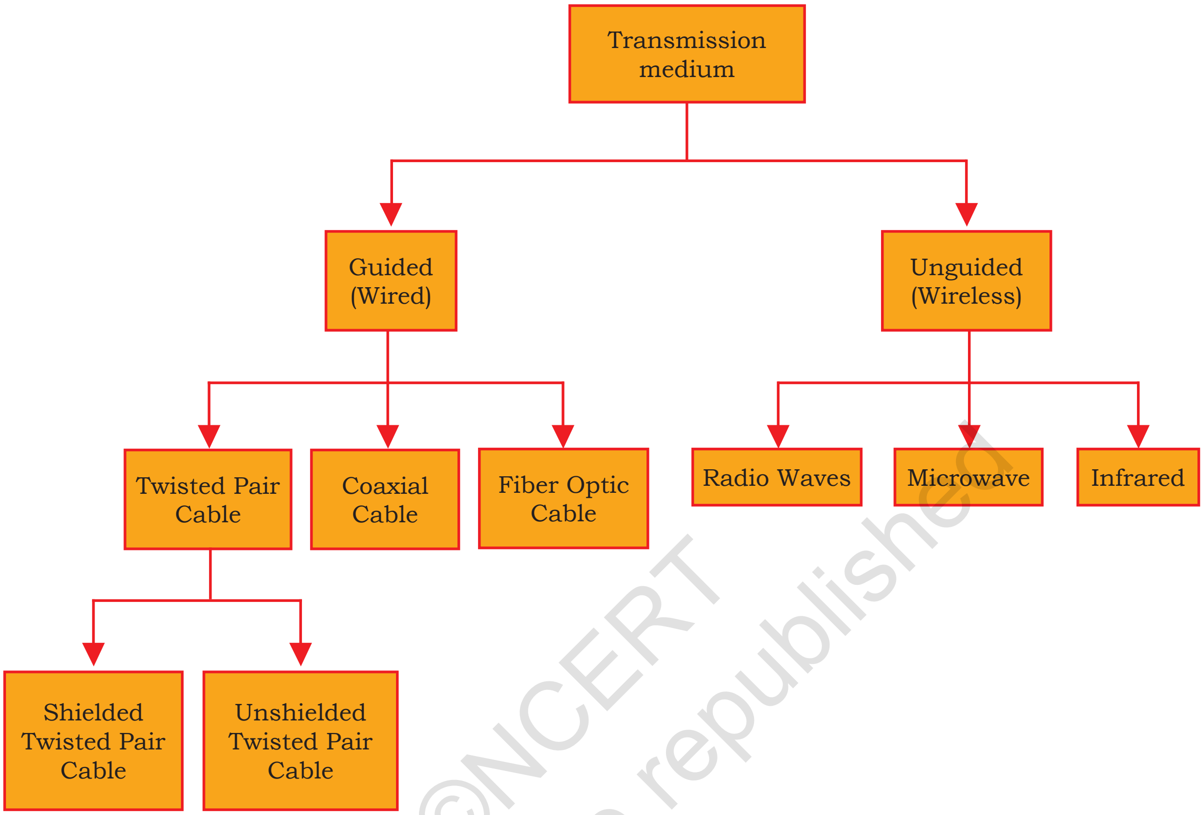


Fig. 2.7: Classification of transmission medium

Guided (bounded or wired) media

Guided transmission media uses a cabling system that guides the data signals along a specific path. Guided media is also known as bounded or wired media. Depending on the type of transmission medium used the bounded media can be further classified into three types —

(i) Twisted pair cable
(ii) Coaxial cable (in the form of electric signals)
(iii) Fibre optic cable (in the form of light)

Twisted Pair (TP)

Twisted pair is least expensive and most widely used for telecommunication. It consists of two insulated copper wires arranged in a regular spiral pattern.

- A wire pair acts as a single communication link. It may be used to transmit both analog and digital signals. For analog signals amplifiers are required about every 5 to 6 km. For digital signals, repeaters are required every 2 to 3 km.
- Twisted pair is the most commonly used medium in the telephone network. Compared to other commonly used transmission media, TP is limited in distance, bandwidth and data rate. When two copper wires conduct electric signal in close proximity, a certain amount of electromagnetic interface (EMI) occurs.
- This type of interference is called crosstalk. Twisting the copper wire reduces crosstalk. Twisted pair comes in two varieties.
  - Unshielded Twisted Pair (UTP)
  - Shielded Twisted Pair (STP)

Unshielded Twisted Pair (UTP)

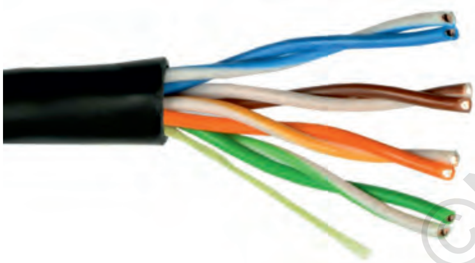


Fig. 2.8: Unshielded twisted pair cable

UTP is a set of twisted pairs of cable within a plastic sheath shown in Fig. 2.8. UTP is an ordinary telephone wire. This is the least expensive of all the transmission media commonly used for LAN, and is easy to work with and simple to install. UTP is subject to external electromagnetic interference. Fig. 2.8 shows unshielded four pair cable.

Shielded Twisted Pair (STP)

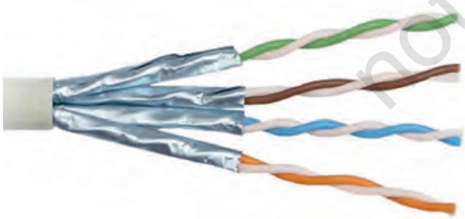


Fig. 2.9: Shielded twisted pair cable

STP offers a protective sheathing around the copper wire. STP provides better performance at lower data rates. They are not commonly used in networks. Installation is easy. Special connectors are required for installation. Cost is moderately expensive. The distance is limited to 100 metres for 500 Mbps. STP will still suffer from outside interference but not as much as UTP. Fig. 2.9 shows the STP cable.

Coaxial cable

- It is made up of two conductors that share a common axis. It consists of a hollow outer cylindrical conductor that surrounds a single inner wire conductor shown in Fig. 2.10.

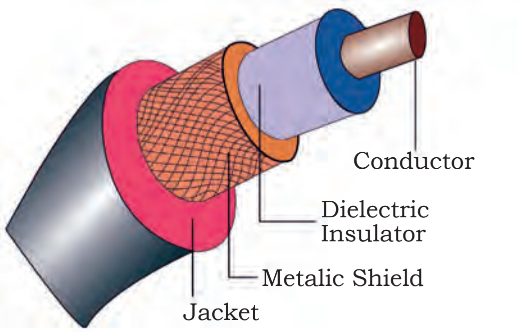


Fig. 2.10: Coaxial cable

- Coaxial cable is used to transmit both analog and digital signals. Data transfer rate of coaxial cable is in between TP and fibre optic cable. Coaxial cable must be grounded and terminated.
- Coaxial cable transmits information in two modes — baseband mode and broadband mode.
- In baseband mode, the cable bandwidth is devoted to a single stream of data. The high bandwidth capability allows high data rates over a cable. Mostly used in local area networks (LAN). In LAN, only one data stream is present at any time.
- In Broadband mode the bandwidth is divided into different ranges. Each range typically carries separate coded information, which allows the transmission of multiple data streams over the same cable simultaneously. Cable television is an example of multiple signals.

Optical Fibre Cable (OFC)

Fig. 2.11: Optical Fibre Cable (OFC)

- OFC is a light pipe which is used to carry a light beam from one place to another. Light is an electromagnetic signal and can be modulated by information as shown in Fig. 2.11.
- Since the frequency of light is extremely high, hence it can not only accommodate wide bandwidths of information, but also higher data rate can be achieved with excellent reliability.
- The modulated light travels along the fibre and at the far end, is converted to an electrical signal by means of a photo electric cell. Thus the original input signal is recovered at the far end.
- OFC transmits light signals rather than electrical signals. Each fibre has an inner core of glass or plastic that conducts light. The inner core is surrounded by cladding, a layer of glass that reflects the light back into core.

- A cable may contain a single fibre, but often fibres are bundled together in the centre of the cable. OFC may be multimode or signal mode.

  Multimode fibres use multiple light paths, whereas signal mode fibres allow a single light path.

Unguided (unbounded or wireless) media

Depending on the method of transmission the unbounded media can be further classified into three types:

- Radio links
- Microwave links
- Infrared light transmission

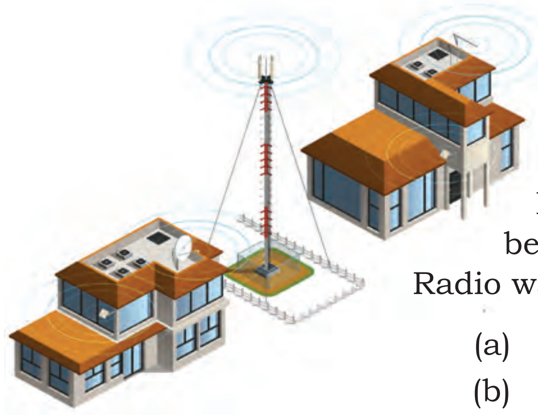


Fig. 2.12: Radio transmission in residential area

Radio links

Radio waves shown in Fig. 2.12 have frequencies between 10 kilohertz (kHz) and 1 gigahertz (GHz). Radio waves include the following types—

(a) Short wave

(b) Very high frequency (VHF) television and FM radio

(c) Ultra high frequency (UHF) radio and television

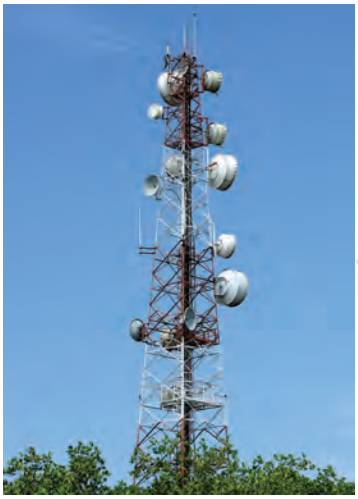


Fig. 2.13: Mobile tower uses microwave for communication

Microwave links

It is a communication system which uses a beam of radio waves in the microwave frequency range above 100MHz to transmit information between two fixed locations on the earth. It consists of a pair of antennas spaced some kilometers apart and is used to send information.

Fig. 2.14: Infrared light is used in TV remote

Infrared light wave transmission

Infrared light waves are widely used for short range communication. The remote control used in TV, VCR and stereos all use infrared communication as shown in Fig. 2.14.

Check Your Progress

A. Multiple Choice Questions

1. Cabling have allowed people across the world to communicate with one another via _____________.
   (a) fax
   (b) phone
   (c) computer
   (d) printer
2. Which of the following is not an element of communication?
   (a) Sender
   (b) Receiver
   (c) Medium
   (d) Node
3. All types of cabling consist of a conductive material protected by one or more sheathing and/or insulation components which is _____________.
   (a) clad
   (b) core
   (c) fibre
   (d) copper
4. Which of the following is not unguided transmission media?
   (a) Radio waves
   (b) Infrared
   (a) Microwave
   (a) Fibre optic
5. Which of the following is not a conducted transmission media?
   (a) Coaxial cable
   (b) Twisted paircable
   (c) Microwave
   (d) Fibre Optic Cable
6. Total internal reflection is a phenomena used in _______.
   (a) endoscopy
   (b) fibre optics
   (c) coaxial cables
   (d) twisted cables
7. Coaxial cabling is found in the following types of networks except _____________.
   (a) cable television
   (b) broadband Internet access
   (c) VHF/UHF antenna connections
   (d) residential telephone networks

8. Coaxial cabling is used in ______________.
   (a) voice messages
   (b) TV signals
   (c) video messages
   (d) audio messages
9. One of the primary disadvantages of fibre optic cabling is ______________.
   (a) cost
   (b) resistance to weather
   (c) interference
   (d) flexibility

B. Fill in the Blanks

1. In half-duplex transmission data can be transmitted in ______________ direction.
2. In simplex transmission data can be transmitted in ______________ direction.
3. The quality of transmission primarily depends on the characteristics and nature of ______________ media.
4. Coaxial cables can be used for ______________.
5. Satellite communication use ______________.
6. Fibre optic cabling is exempt from the problems of ______________ and ______________ interference.
7. Fibre-optics work on the principles of ______________ and ______________.
8. Cable transmissions result from the generation of signals using either optics or ______________.
9. The most common types of interference are ____________ and ______________.
10. The three major types of cabling include ______________, ______________ and ______________.
11. Twisted cable can be used for the distance of __________.
12. Light propagates inside the fibre cable using principle of ______________.
13. Core of the fibre is made up of ______________ and ______________.
14. The twisting in the twisted-pair cables reduce the ______________ which is generated due to the electromagnetic interference.
15. The principle to ______________ is responsible for the optical signal propagation in fibre optic cables.

C. State whether True or False

1. Electromagnetic is a type of radiation in which both electric and magnetic field do not vary.
2. Bandwidth is defined as a range of frequencies within a given band which is used for transmitting the signal.
3. Fibre Optics is more practical and widely used as the transmission medium for optical communication systems.
4. Fibre-optic networks form the core or backbone of the Internet.
5. A major disadvantage of fibre-optic cables is their limited information-carrying capability.
6. Fibre optics cables are cheaper than coaxial cables.
7. Speed of light in free space < speed of light in water < speed of light in glass.

D. Answer in one sentence

1. What are the major components of telecommunication?
2. What are the different modes of fibre optics communication?
3. Who was the father of fibre optics communication? How did it bring about a change in the field of communication?
4. Define electromagnetic spectrum.
5. List the different range of frequencies with their applications.
6. What are the standards of twisted cable wires?
7. Which type of light source is used in single and multi-mode fibres?

E. Short Answer Questions

1. How does the telecom growth benefit the nation?
2. On what parameters the quality of transmission depends in case of guided transmission media?
3. Why wires are twisted in case of twisted pair of transmission medium?
4. Give a popular example where coaxial cables are used for broadband signalling.
5. In what way do multi-mode and single-mode fibres differ?
6. Give practical examples used in our daily lives where different modes of communication are used.

Notes

7. State eight benefits of fibre optics cables over electrical cables for communication. Name six typical communication applications for fibre optic cable.
8. Explain how light is propagated through a fibre optic cable. Name the three basic types of fibre optic cables, and state the material from which they are made.
9. Explain in detail the various elements of fibre optics communication.
10. Define wireless communication. State different types of wireless communication.